

# The Pros and Cons of Different Construction Systems

By Clive Fewins

## Note

*This article appeared in a recent issue of 'Home Building & Renovating' - a magazine targeted at the UK market (see: <http://www.homebuilding.co.uk/>)*

*Although it provides much useful information on the pros and cons of different construction systems, readers must remember that:*

- *The climatic and seismic conditions in Cyprus are completely different to those of the UK.*
- *Not all of these construction systems are available in Cyprus.*
- *All property built in Cyprus needs to comply with strict government anti-seismic regulations.*

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## **How will you build your house? Brick and block, timber frame, or one of the alternatives? Clive Fewins looks at the pros, cons and relative costs of each system.**

Many people are surprised to learn that the brick, stone, render or timber that make up the outer walls of a modern house play little or no structural role. Although they help keep the building warm and dry, they are otherwise only decorative. The task of supporting the floors and roof is usually played by an inner structure - usually concrete blockwork. With the exception of oak frame, the choice of this construction system, therefore, can be considered largely independently of the architectural style of the building.

Traditional masonry cavity walls, most commonly brick with an inner structural leaf of concrete block, have dominated housebuilding in the UK for the past eighty years, but there are a number of other systems that are gradually making inroads, including timber frame, steel frame and now new systems such as Structural Insulated Panels and Permanent Insulated Formwork.

One question that perpetually raises its head is 'which is cheapest' of the two most prevalent systems - timber frame or brick and block? The answer: it depends. However, before you get involved with trying to answer this question it is worth considering all of the other forms of construction.

In many areas of the UK, systems that originated on the other side of the Atlantic, like SIPs - Structural Insulated Panels - are making great inroads. Many architects look very favourably on this system, in which a series of lightweight panels comprising sheets of plywood laminated to a core of expanded polystyrene insulation board, are bonded

together by a simple slotting-in system to form the walls and quite often the roof too.

A few years ago Permanently Insulated Formwork (PIF systems) fell into this 'new' category, but today it is a method of solid wall construction that is well established, while steel frame, a system last used extensively in the 1940s and early 1950s, is being tipped by industry insiders as hot favourite for the housebuilding system of the future.

If professionals appear reluctant to be dogmatic on which systems are more economic, it is probably because there is no definitive answer. If you are building a house in Scotland, there are so many timber frame companies that it might well be cheaper than masonry, while there are certain to be areas of the UK where domestic construction companies have a strong market and have got cavity walling systems down to a fine art. Cost is unlikely to be the main consideration, anyhow, as the construction system is only likely to represent 15 per cent at the most of the overall construction costs.

If you want to build fast, then timber frame or SIPs are probably the route for you. If you want a flat roofed house shaped like a guitar, then cast concrete or PIFs may well be best.

If you are not a building professional and want to build the outside walls of your new self-build yourself, then it is not hard to find someone who can tell you the essence of building in brick and block. Though progress may be slow, you are unlikely to fail if you seek good advice. There are many factors to take into consideration when it comes to specifying the best structure for your new house. On the following pages we look at the advantages, disadvantages and relative costs of each of the many systems available, along with a comprehensive directory of the major suppliers in each field.

## **Masonry**

The vast majority of houses built in the UK have walls of masonry - but that does not necessarily mean they have a cavity. Until the 1920s almost all houses were built with solid walls - frequently of what was known as 'nine inch brick'. However, cavity walls were also known to the Victorians, a practice they called 'hollow wall construction'. As early as 1805 it was pointed out that 'hollow walls', as they were known then, could be much warmer than solid walls because of the air trapped in the cavity between.

A cavity wall comprises three elements: an inner and outer leaf of masonry and an air space between. The modern cavity wall, with wall ties between the skins, drip trays over window openings and insulation in the centre, only came into its own in the 1930s, when it was common to have a 225mm (9") inner skin.

The width of the cavity for many years was generally 50mm, but nowadays it is more likely to be 75mm in order to accommodate the thickness of cavity insulation required to achieve the 0.35 u-value as stipulated by building regulations.

### **Advantages of Masonry Walls**

The materials and skills required to build in masonry are widely available across the UK. It is therefore possible to start building work in masonry almost instantly. It should be

possible to build two skins of blockwork and render the outside for less than £40/m<sup>2</sup>. With a brick skin expect to pay up to £20/m<sup>2</sup> more, depending on your choice of brick.

Masonry cavity walling is therefore almost certainly the cheapest structural system for your new self-build - although the difference will be marginal on a one-off house and so relative cost should be considered in the context of the other pros and cons of the alternatives.

A masonry structure gives a house a feeling of solidity, as the density of the blocks provides a high level of acoustic mass, helping to deaden noise outside the building. Building internal partition walls from masonry, as opposed to timber stud walls covered with plasterboard, will further enhance the feeling of solidity and provide sound deadening between rooms.

The high strength of masonry walls allows the option to use suspended concrete upper floors, rather than conventional timber floor joists. This provides sound deadening between storeys, as well as making it possible to build first floor partition walls in solid masonry, rather than in timber studwork, extending the qualities of solidity and sound deadening to upstairs rooms. Dense blockwork also provides a solid fixing for built-in furniture, curtain rails, pictures etc.

With the addition of steel, or glue-laminated timbers, masonry is extremely versatile and is suitable for the construction of most house designs. However, ordinary dense concrete blockwork is a poor insulator and so in order to meet the energy requirements under the building regulations, insulation has to be added into the wall structure. It is possible, however, to achieve extremely high levels of energy efficiency using masonry construction.

One way of improving the thermal performance of a masonry structure is to use lightweight concrete blocks – also known as aircrete. These have a proportion of air added into the mix during manufacture, creating tiny air bubbles which act as an insulant. The disadvantage is that the more air that is added into the blocks, the weaker they become. This can be a problem when it comes to fixings as special anchors are often necessary to fix heavy furniture or curtain rails.

### **Disadvantages of Masonry**

Whilst it is possible to increase the thermal performance of masonry walls to achieve very low U-values, there are limitations to how much insulation can be added within the cavity - the cavity cannot be built much beyond 100mm without creating structural problems.

The alternatives are to use high performance partial fill insulation products, such as urethane boards, which have a relatively high cost factor, or to fully fill the cavity. This does raise concerns over damp penetration, especially in harsh weather areas where many local authorities do not allow it.

The other alternative is to add insulation on the inside face of the walls, which presents a whole different set of issues, not to mention additional labour and material costs.

As a form of 'wet' construction, masonry needs time to dry out between blockwork 'lifts'. As a result, masonry is likely to be slower than timber frame construction.

The tall, slender walls in cavity construction may also be prone to settlement cracks. There are also fears over the cleanliness of the cavities, the fear being that if too much mortar is allowed to drop on cavity ties above the damp proof course level, or besides the insulation bats, bridges could be formed that might transfer damp to the inner skin. It should be remembered, however, that where a timber frame structure is clad in brick or blockwork, the cleanliness of cavities is also an issue.

Another disadvantage is that masonry cannot be laid when it is raining heavily or when temperatures fall below freezing. This is one reason for the popularity of timber frame construction systems over cavity systems in Scotland, where the climate can be aggressive. With timber frame much of the construction process takes place in a factory and the frame is then erected on site in days.

### **Dense or Lightweight Blocks?**

For cavity walls, lightweight aircrete blocks are often the preferred choice in domestic construction nowadays, but many architects and engineers prefer medium density concrete for the outer skin, although its thermal qualities are not as good. This is because, in the words of one experienced architect, aircrete blockwork is 'like a sponge' and the result is that renders are in danger of cracking, especially because these blocks settle more than their denser counterparts. Even if it takes a render well, many architects and engineers avoid aircrete blocks because of settlement problems, especially if they have an external render. The fear is that with a crack the wet will get into the cavity and find it very hard to get out.

Because of settlement issues and the greater risk of cracking – this is not a structural problem – manufacturers of aerated concrete blocks recommend bed joint reinforcement. This involves inserting strips of expanded metal in every third or fourth course going up horizontally. This spreads movement over the entire outer block wall. It is a less obtrusive but more labour-intensive way of creating expansion joints in the walls.

A further criticism is that solid aircrete, being relatively water-absorbent, often contains a very high moisture content in the structure of the walls long after construction. This is particularly so if water is allowed to penetrate into the blocks if they are stored outside prior to being used, so the humidity stays in the wall and the thermal performance is reduced. Medium density concrete blocks soak the water out of the mix far less and have a surface into which a render keys well. They are also considerably cheaper than aircrete blocks.

### **Thin Joint Blockwork Systems**

These aircrete blockwork construction systems arrived in the UK from Scandinavia and other European countries and are now widespread.

Thin joint blockwork saves time because the blocks are longer and often wider than the standard 610 x 215mm and lead to a more airtight shell because there is far more insulated blockwork and less mortar. They are, according to the manufacturers, more economical because you can build faster and achieve higher insulation values (often without the need to add internal insulation) than you can with conventional aircrete blocks.

Instead of using a conventional mortar, thin joint systems use a special glue mortar laid in beds just 3mm deep (as opposed to 10mm beds). This increases the insulation value of the walls as there is far more blockwork than mortar than in conventional aircrete walls. It also allows walls to be built up extremely quickly, thus reducing labour costs.

Some builders and architects do not like these systems because they think they demand too much of the bricklayer - too high a degree of precision. This is because the tolerances are very fine and there is little room for error. However if you get the setting out correct in the first place there should be little problem.

One building control officer says: "If the blocks are not laid perfectly level - and this is difficult considering how thin the joints are (3mm) - it is very easy to get gaps at the higher levels. Unlike a cement or lime mortar the jointing compound will not fill these gaps so you have to leave small holes in the structure." Many architects and builders consider thin joint masonry a system for new-build and not extensions because it does not lend itself to adding onto blockwork of different sizes and widths. One experienced contractor said the tolerances to which the blocks are manufactured do not always take account of the 3mm joint size and therefore the blocks are sometimes too big for the very accurate spaces allotted for them.

## **Solid Masonry Walls**

There are many advocates today for building houses with solid blockwork. In much of Europe solid wall systems are used, generally involving lightweight aircrete. These systems are slowly catching on in the UK, especially for extensions.

"Turbo" top strength aircrete blocks 265mm thick are favoured by many builders because of the speed of erection - the wall is just one block deep - and insulation value. To achieve the required U-value of 0.35 you would need to add 50mm of thermal board insulation on the inside. However it is still reckoned not to be much cheaper than two skins with insulation in between.

When used in solid wall construction it is important to apply a two part render with a waterproofer on the outside. Many advocate using a hydraulic lime render, because that way the need for expansion joints is avoided.

Solid blockwork can also be used a backing for stone faced walls. In this specification, the block must be waterproofed with bitumen.

## **U-Values**

A U-value, as measured in  $W/m^2k$ , is a measurement of heat loss, so that the lower the U-value, the less heat is lost through your walls. The latest elemental requirement for walls, as outlined in the 2002 Building Regulations, is 0.35.

## **Construction Alternatives**

**Wood Blocks:** The Steko wood blocks system from German engineered timber specialists Merk, available from Construction Resources in London are a dry precision construction system of large hollow softwood blocks made from glued board offcuts of softwood. The interlocking blocks stack quickly, secured with vertical dowels. It is a dry construction method: no other means of fixing is needed. All blocks are 160mm thick and are stuffed with loose natural insulation. It is possible to upgrade thermal performance by adding insulation to the exterior surface of the block. The planed timber finish for the internal walls can be left untreated. Externally there are many alternatives: a favourite is facing bricks but a coat of lime plaster is also quite possible.

**Straw Bale:** Densely bound straw bales are either fitted non load-bearing within a structural post and beam system or, as the purists prefer, taking loads themselves on a ring beam fitted round what is in effect a block wall. It is a system that appeals greatly to the eco-minded because straw is an agricultural waste product, it is easy to handle and it is, of course, renewable. Straw bale construction also has excellent insulation qualities and is extremely cheap. With straw bale building it is essential to have an external render to keep out the wet. The system has the disadvantage of width – it is heavy on space – and problems with water vapour at the junctions with other materials.

**Others:** Other alternative construction techniques include hemp blocks and rammed earth.

## **Timber Frame**

Timber frame systems have gained much popularity in recent years. It is reckoned that in excess of 70 per cent of the new homes in Scotland are built using this system and there is little doubt that it is gaining popularity in England too. Modern panel timber framing is thought to have been invented in Chicago in the 1830s. Instead of walls being built in situ as the house went up, they were hammered together in frames and then hoisted into place.

The fundamentals of timber frame are simple: it is much more of a house skeleton than a wall. Wall panels – usually prefabricated – made from relatively small sections of timber, are bound together and braced, usually by means of sheets of plywood or something similar onto the outside of the timber outer wall. You usually leave a 50mm clear gap between this and the outer cladding. In the UK this is very commonly brick, but it can equally be stone, weatherboarding, hung tiles or render laid on stainless steel mesh attached to battening.

## **Glulam Beams**

Glulam – Glued Laminated Timber – can be used for roof and floor beams and joists. It can be engineered to shape and its strength enables it to span large open spaces (over 50m). As a result of this – and its relative cheapness – the material is gaining popularity in domestic applications, including post and beam frames.

## **Advantages of Timber Frame**

Timber frame systems have always been popular with self-builders because they are fast and convenient. With the main components assembled in the factory and transported to the site, the roofs and walls go up far quicker than with a conventional masonry system. A timber frame structure can be erected and weathertight within a matter of days and work can begin on first fix inside whilst the roofers start on the tiling.

Another advantage is that you can often deal with just one company, which will design, manufacture and erect your timber frame. Very often the company will also supply the roof structure, windows and doors.

Timber frame houses are also excellent from an insulation point of view. Nowadays the standard timber frame sections of 89mm have to be augmented by extra insulation on the inside in order to conform with the U-value requirement of 0.35. However many companies are now offering 140mm as standard, a practice which some timber framers refer to as “super insulation.”

Many self-builders also like the idea of living in a house where the main frame is constructed from a sustainable resource where the timber source is guaranteed to have come from renewable, carefully managed forests.

However, if timber frame is your choice you should remember that the law of diminishing returns applies: the energy savings achieved by super-insulated walls are surprisingly small and should be balanced against not just installation costs but loss of internal floorspace in situations where the planners dictate a maximum area for the footprint of the house.

## **Structural Insulated Panels**

This is an idea that has been around since the 1950s but it really took off in the USA about 10 years ago. It can best be described as timber frame without the timber. By laminating sheets of plywood or OSB round a core of expanded polystyrene insulation board you get a board that can be used both as a rigid roofing board and for wall panels to which all manner of claddings can be fixed. SIPs have the advantage of being factory-produced and made to measure for particular building projects. In roofs they can also be swung into place easily and fixed rapidly to aid rigidity.

Only in recent years have British companies seen the advantage in using them for walls as well as roofs but today they are used for both. There is a strong argument in favour of using both together because of the insulation values and the fact that roofs constructed

from SIPs panels avoid roof trusses and so with the addition of rooflights can easily be used as extra bedrooms.

SIPs usually arrive quite quickly when you order them. They are structurally very efficient and also score very highly on thermal qualities, speed of erection and not having to be kept dry whilst awaiting erection.

## **Disadvantages of Timber Frame**

With most masonry systems the materials are readily available. Once you have your planning permission and have found a builder you can get the materials very rapidly and start. With timber frame a waiting period of 12 weeks is not unusual. Beware, too, of hanging heavy objects on the inside walls. If you wish to turn the inside of your house into a picture gallery then timber frame, with its lightweight stud walls covered with plasterboard, is not for you - although this problem can be largely overcome for a few hundred pounds by the use of fibre reinforced plasterboard. Another possible disadvantage is that unless you have high quality labour it is very easy in timber framed houses with brick outer skins to get water penetration round window and door openings.

Timber frame is also usually more expensive than brick and block, although most timber frame companies would argue that if a self-builder opts for 140mm stud walls, which give a U-value of less than 0.30, the additional costs will generally be recouped in a few years by reduced heating costs.

Others argue that timber frame is acoustically inferior to brick and block. The fact that with timber frame the walls are largely hollow counts against it when it comes to sound proofing. However this is a tricky one because sound travels in two ways - through the air and through impact. While masonry will tend to absorb airborne sound better because it is denser than timber frame, impact sound can be transmitted through all kinds of materials and there are many cases of masonry houses built with heavy concrete intermediate floors which have failed to meet the impact sound requirements of the Building Regulations. Good detailing in timber frame housing can reduce the effect of airborne sound transmission so that it matches the best a masonry house can achieve. It is also possible to add further products specifically designed to improve sound insulation, but these all add to the cost of the house.

Timber frame construction using panels does not lend itself to large spans. If you wish to have a really large reception room you may need to resort to using a post and beam structure.

Whilst timber frame clad in timber is one of the cheapest finished walling options, timber frame can be a relatively expensive choice if the walls are to be clad in natural stone. A greater thickness of stone, or a backing block, will be required to increase rigidity.

## **Open Panel vs Closed Panel**

The prospective purchaser of a timber frame should be aware of the difference between the 'open' and 'closed' frame systems. These are essentially the British system against the Scandinavian.

Closed panel systems are when the entire wall is built in the factory and just craned into place on site. In this way it is possible to assemble a finished house in hours. It also ensures an even standard of quality control.

Open Panel is the more common system in the UK. Boarding is fixed to the outside of the panels in the factory. The inner face of the walls, including the insulation, is completed on site. The semi-finished open panel method tends to suit British self-builders better than the fully-finished Scandinavian systems, in which all the service pipes and cables are incorporated in the factory produced walls. The reason for this is that many British self-builders do not have fixed ideas about how they will finish off their homes at the stage when the frame is delivered.

## **Post and Beam**

Whereas with a conventional timber frame house the load is spread across the external wall panels, a post and beam frame carries the load on an internal skeleton of larger section timbers. The outer wall panels, usually timber frame but now sometimes structural insulated panels (SIPS), act simply as a cladding.

This form of construction is useful in timber frame houses where there are to be lots of openings, for example open plan ground floors or where there are lots of big windows or patio doors. This method helps in planning interesting spaces and also in creating an aisle frame design if desired. It also lends itself to creating cathedral ceilings in single storey sections or in first floor rooms.

## **Oak Frame**

Oak framing is currently very fashionable. It is unique in that it is a means of building in which the structure is visible both inside and outside. The load is borne by an outer skeleton of oak posts and beams. The technique used to build in oak has changed very little since mediaeval times. Oak is particularly strong. As it dries out it shrinks across the grain and this causes the joints in the cellular structure to tighten up, making the frame even stronger than when first built. This drying process also causes minor splits – known as shakes – along the frame. This can frighten self-builders but is part of the natural process and, as you will see from many an old oak-framed house, adds greatly to the building's charm.

Building in oak will cost you at least a third more than standard timber frame. You should work on at least £1,000/m<sup>2</sup> for a house built in this way, though oak frame turnkey packages can work out cheaper.

Oak will last virtually forever as long as no part of the frame is allowed to stand in water. It does not need treating with preservatives because it is naturally resistant to weathering and insects.

Exposed external timbers and internal frames all add to the beauty of oak framed houses. Many architects specialising in this style also glaze some of the external panels, producing an effect that has the light quality of a contemporary house but with a highly traditional feel. Such architects can also design 'hybrid' oak frame houses in which softwood is used in stud walls and areas of roof in which the frame does not show, thereby reducing the cost. Sometimes a complete oak framed first floor is placed on a less expensive blockwork ground floor - a very effective technique for houses in which the main living rooms are to be upstairs.

Not being dependent on many smaller timbers and a wealth of internal load bearing stud walls, oak frame also allows for a flexible internal layout and the great strength of the material means you can build in design ideas like open feature trusses, curved windbraces, double height rooms and galleries. Further, with an oak frame the bays can be assembled in more or less any permutation to produce interesting and varied plan forms.

The oak frames for houses are fabricated in the workshop and the joints are finished off by hand using traditional joints. When the frame is erected on site the means of joining these is tightly cleft oak pegs. Many oak framing specialists sandblast the entire frame after erection to take out the iron stains to which oak is so susceptible as a result of sawing in its green state.

## **Steel Frame**

Steel framed houses are a rarity in the UK. Nobody seems to know quite why, because in the USA and Australia they are very common. Steel framed housing did enjoy a spell of popularity in the UK in the 1940s, but today houses built in this way are estimated to embrace less than one per cent of the UK housing stock. However, there are some signs of a revival. A handful of small manufacturers produce systems of this sort and are aiming them at the self-build market. They would appear to have a great deal to recommend them.

Basically steel framing, like timber framing, is a form of part-prefabrication. Today's steel frames for houses are a latticework of lightweight C-sectioned galvanized steel, to which sheathing board and insulation is applied to the outside before the whole is usually finished off with a render.

Steel framing of this sort is infinitely cheaper than the massive I- and C-beam systems we see in the shells of new commercial developments and factory units. This sort of frame is only considered necessary for a house when there are extremely large spans needed.

## **Advantages of Steel Frame**

Lightweight steel frame is faster to erect than timber frame, fireproof, and highly accurate as it is factory-produced and transported to the site in sections. As it is strong it allows for large internal open plan spaces. It also appears to compare very favourably in price with what is generally recognised as the cheapest means of building - dual skinned blockwork. Some systems allow for the sections to be produced and assembled on site. Insulation is easily installed: some systems have walls with a U-value of 0.7 and houses built in this fashion are easy to extend and modify.

## **Disadvantages of Steel Frame**

The main one appears to be public perception. Despite the fact that thousands of homes have been built in this way in other countries British people somehow seem to think it is both expensive and in some way difficult to achieve. Neither is true.

The other obvious disadvantage is sound transmission. Steel framed houses are potentially poor from the point of view of sound transmission. In the case of airborne sound this can be overcome by packing the frame with quilting. In social housing with party walls, impact sound, which is transmitted through the floors, can present more of a problem. However in individual self-builds, where the floors are of timber or chipboard, this is less of a problem as the noisy elements can be isolated and dealt with individually.

One company experienced in steel frame construction that is now turning its sights to the self-build market is Cressey Engineering. They claim to be able to build a complete 150m<sup>2</sup> house in 12 weeks at a cost of around £550/m<sup>2</sup> all in.

Another young company, Bristol-based Metek Building Systems uses steel rolling machinery that can be transported onto site to convert steel coils into cold-rolled steel frames for fast track buildings. In the housing field this has so far only been used for social housing but the company is also now looking at the self-build market. Managing director Dr Alan Rogan quotes a price of £30/m<sup>2</sup> for finished wall frames. The company can also supply full insulation and a choice of a brick slip or rendered walls. They do not generally supply roofing systems. "There are no real disadvantages with this system," Dr Rogan says. "We can offer bespoke frames extremely quickly – sometimes within 24 hours – the system is very good thermally and acoustically and also easy to extend."

## **Permanently Insulated Formwork (PIFs)**

The idea behind PIFs is that you start with a delivery of hollow interlocking polystyrene blocks, rather like giant light pieces of Lego, and stack them up into the shape you require. You then pour concrete into them - occasionally reinforced with steel and they remain in place permanently as insulation. The difference with PIFs is that with conventional poured concrete you remove the formwork after the material has set. The polystyrene can be rendered on the outside, though many self-builders prefer to add a brick skin. The system is so easy to use that it is ideal for DIYers.